

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
14 February 2002 (14.02.2002)

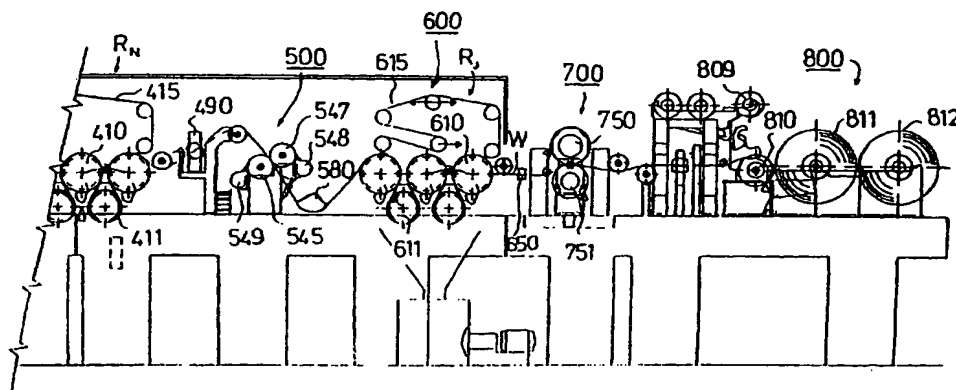
PCT

(10) International Publication Number
WO 02/12620 A1

- (51) International Patent Classification⁷: **D21H 19/54 //** **D21F 11/04**
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- (21) International Application Number: **PCT/FI01/00696**
- (22) International Filing Date: **6 August 2001 (06.08.2001)**
- (25) Filing Language: **Finnish**
- (26) Publication Language: **English**
- (30) Priority Data:
20001773 **10 August 2000 (10.08.2000)** **FI**
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- (81) Designated States (national): **AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.**
- (84) Designated States (regional): **ARIPO** patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), **Eurasian** patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), **European** patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), **OAPI** patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:
--- with international search report

[Continued on next page]

(54) Title: **METHOD FOR MANUFACTURING A COATED FIBRE WEB, IMPROVED PAPER OR BOARD MACHINE AND COATED PAPER OR BOARD**



(57) Abstract: The invention concerns a method and an improved paper machine for making a surface-sized paper web. Pulp is supplied from the headbox (100), wherein additives and/or fillers and/or fines are admixed into the pulp, to the wire section (200), where water is removed from the web (W). From the wire section (200) the web (W) is guided to the press section (300) to press water from the web (W). The web (W) is then dried in the front drying section (400), whereupon the web (W) is surface-coated in the coating section (500) and dried in the post-drying section (600). Finally, the web (W) is reeled by a reeler (800). According to the invention, in the headbox (100) starch and optionally hydrofobic size are admixed or layered into the pulp to be supplied to the wire section (200), so that on at least one side of the web (W) an essentially dense surface is formed, on which in surface-coating a coating paste is spread out, which has a high dry matter content, whereby a bond is achieved in direction z inside the web (W) between the base paper and the surface-coating layer spread out on the surface. The invention also concerns a surface-sized paper, wherein according to the invention there is a bond in direction z between the surface-coating layer and the base paper.

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Method for manufacturing a coated fibre web, improved paper
or board machine and coated paper or board

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The present invention concerns a method according to the introductory part of claim 1 for making a coated fibre web, such as a paper or board web, an improved paper or board machine according to the introductory part of claim 10 and a coated paper or board according to the introductory part of claim 19.

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The method and paper or board machine according to the invention may be applied very largely to the manufacture of such different paper and board grades, where the conventional method would improve the quality of the paper or board by pre-coating. Typical such writing and printing papers are fine grade paper, LWC base paper or improved newsprint, which as such are known to the professional in the field. Coating of various board grades has also increased in recent years. However, in the following the invention will be described mainly in connection with fine grade paper, but without limiting the invention hereto in any way.

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20 In this presentation, fine grade paper means uncoated fine grade paper and coated fine grade paper. The grammage of uncoated fine grade paper is usually 40 ... 230 g/m², while of coated fine grade paper it is 60 ... 250 g/m². The typical pulp for making fine grade paper includes chemical fibre: short fibre obtained e.g. from birch and eucalyptus wood, and to this is usually added long-fibred material obtained from
25 softwood.

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The share of mechanical pulp is usually less than 10 %. About 15 – 30 % of filler is added to the pulp, and the filler may be stone, calcium carbonate, kaolin and/or other suitable mineral pigments. Lately, makers of fine grade paper have also begun using
30 more and more recycling fibre.

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As was mentioned above, the method and paper machine according to the invention may be used advantageously for making paper equivalent to pre-coated fine grade paper. In this application, traditional pre-coating is used with a view of providing the web surface with certain properties advantageous in the further treatment of the web.

5 Such properties are e.g. the desired surface porosity and pore size distribution along with the desired oil absorption level, e.g. measuring with the Cobb-Unger method. The degree of pigment coverage is also one property which should be observed. With the process of making fine grade paper according to the invention, wherein traditional pre-coating is not applied, equal values are thus achieved for the said

10 properties as when using a conventional manufacturing process including a pre-coating step.

As with coated fine grade paper, the invention may also be advantageously applied to paper grades containing mechanical pulp, which are coated in the final stage of

15 the manufacturing process. LWC and MWC are typical such paper grades.

With the method and equipment according to the invention it is also possible to make better newsprint than before without any surface-sizing unit. This significance of the invention becomes more significant with increasingly speedy newsprint

20 machines or with newsprint which becomes more and more thin. Four-colour printing requires a harder and denser surface than before. As is known, it has been proposed earlier that this can be achieved by surface-treatment of the web.

A better printing surface than before is more and more often demanded of boards.

25 The invention offers good possibilities in this regard without any expensive investments in the dry end of the board machine. For the manufacturing of multi-layer board, the invention also offers an advantageous solution to improve the printing characteristics of the webs forming the surface layers of multi-layer board. The inter-laminar strength of multi-layer board can also be improved by supplying

30 e.g. starch on to the web surfaces.

In known state-of-the-art paper or board machines, the short circulation and the other pulp system is usually constructed in such a way that it mixes the fibres, fillers, fines and additives into a pulp as homogenous as possible to be supplied to the headbox of the paper or board machine. It is also known in multi-layer web formation to use several separate pulp systems in order to supply different fibre suspensions to either one headbox or more headboxes. The headbox spreads the resulting pulp suspension evenly on to the wire section, where dewatering and couching of the web will begin. The state of the art knows several wire sections or formers of various types which are known as such to the professional in the field; Fourdrinier wires, hybrid formers and jaw formers. Board machines may even have several wire units. From the viewpoint of the invention, the most advantageous former is the jaw former, wherein a lip discharge formed by the headbox is run in between two wires and most of the water is removed in between the said wires in two directions. An advantageous jaw former solution was described in the paper *L. Verkasalo: Efficient Forming at High Speeds, XI Valmet Paper Technology Days 1998*. In known state-of-the-art solutions, it is possible only in part to control the fibre and filler distribution in the thickness direction of the web, e.g. by the location of the former's dewatering elements and by negative pressures. Fillers often enrich on web surfaces in the dewatering stage.

Multi-layer headboxes are known as such in the state of the art, one of which is presented e.g. in the paper *M. Odell: Multilayering, Method or Madness?, XI Valmet Paper Technology Days 1998* and one of which was also described in the paper *P. Ahonen: Challenges for Digital Printing Paper, XI Valmet Paper Technology Days 1998*. Using multi-layer headboxes desired layer structures are brought about in the web by feeding the layered pulp into the space between wires. Especially with some board grades several different headboxes and wire units have been used instead of a multi-layer headbox in order to bring about a layered structure.

From the wire section the web is taken to the press section, wherein water is removed from the web by pressing it against one felt or two felts. The professional

knows several different state-of-the-art press solutions, e.g. the applicant's press marketed with the SymPressTM II trademark, which is based on roll nips. Lately there has been an increasing use with all paper and board grades of a long nip known as such in the art instead of roll nips due to its better dewatering ability and/or due to the web's bulk preservation ability.

In known state-of-the-art paper and board machines, the drying section is usually formed by a conventional drying section using single and/or two wire transfer, by which drying mainly takes place as cylinder drying as the wire presses the web against a heated cylinder surface. In recent years the use of single-wire transfer through the entire drying section has increased with high running speeds. As the latest solution e.g. patent application *PCT/FI98/00945* proposes a combination of blowing-on with cylinder drying in order to achieve a higher evaporation speed and a shorter drying section.

In some known state-of-the-art solutions, the paper web is guided from the drying section to a pre-calender, which in the known solutions may be a calender with a hard or soft nip, wherein the paper web is guided from the nip between rolls in order to achieve a smooth paper web surface. The pre-calender is also used for fastening loose fibres or other pulp components to the web surface, but at the same time possibly also causing density differences in the base paper and losing web bulkiness, which is important to many grades. Pre-calendering is especially important before the web is coated when using blade coating to avoid so-called blade lines.

According to the known technology, the web surfaces are pre-coated with a starch or pigment solution after the drying section or after pre-calendering, for example, using an applying device of the film size press type marketed under the applicant's trade name OptiSizerTM. In this step, pre-coating is typically done on both sides of the web at the same time, but the web surfaces may also be pre-coated separately in successive units. The paper web is then dried using infra driers and air-borne web driers and a short bank of cylinders following after these.

Then, as is known in the art, the web is surface-coated by blade, roll or jet coating units known as such in the art, and it is dried using infra and air-borne web driers as well as cylinder drying. The dried paper or board web is reeled, whereupon a multi-
5 nip calender follows, which is used to give the paper or board the desired grade of smoothness and gloss. On-line calendering has also become more widely used lately.

On the other hand, in some known state-of-the-art solutions a calender and reel-up
10 often follows after the drying section. An unwinder then follows, from which the web is guided to an off-line coating station. There are different known state-of-the-art coating stations. In one known solution pre-coating of one side of the paper web is first performed, whereupon the drying section follows, and then the other side of the paper web is pre-coated, whereupon the drying section follows. The resulting
15 pre-coated web is finally coated with other coating layers and the web is then dried and reeled. Unwinding then follows as well as calendering and reeling of the web. The final machine after the drying section may thus be an on-line or an off-line machine.

Before coating, the paper may thus be very porous, as is known in the art, so after dewatering and drying treatments the paper web must be pre-coated before the actual surface coating. This also means that the paper web must be dried after pre-coating, so that the coating proper can be added to the paper web surface. The equipment and web transfers needed for these steps add considerably to the length of
25 the fine grade paper manufacturing line. This double coating, that is, pre-coating and actual surface coating, of fine grade paper has aimed at achieving a coated paper surface, which is physically and visually even, as a printing basis. The most important task of the pre-coating in the said coating process is suitably to diminish pores existing in the surface structure of the base paper or board, so that the surface
30 coating will remain on the surface and will not sink into the paper or board structure. If the coating is distributed very unevenly in the paper or board surface, then the

paper or board will be uneven even after it has been surface-coated, and it may have e.g. gloss spottiness or other visual faults. E.g. with a film transfer technique it is possible to achieve an even surface-coating layer and thus good coverage, which is a desirable property especially in the pre-coating stage, because an even pre-coating is a precondition for an even surface coating. After pre-coating, surface coating of the web is performed in known state-of-the-art blade coating in order to achieve an even surface. However, this makes space demands on the paper or board finishing line, because the paper or board is coated in 3-4 different steps, since the different sides of the paper or board web are often coated in different steps.

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In known state-of-the-art paper and board machines, a size press or a coater of the film transfer type is thus generally used for pre-coating of the web. Hereby surface size or some equivalent coating material is supplied as an aqueous solution on to both sides of the paper web in one or two steps with the purpose to bind fines and fibres into the web surface and thus bring about favourable conditions for a possible following coating. In known state-of-the-art solutions, where a separate pre-coater is thus used, it is a problem that the length of the paper or board machine or of the coating line increases. This adds to the investment costs of both the machine itself and also of the building. Lack of space in renewals may actually prevent introduction of new technology. When aqueous matter is spread out on the web, drying will be needed, which both increases the machine length and adds to the investment costs and which also increases the need of drying energy. In addition, open transfers must be arranged in the paper machine, which may cause web breaks and other runability problems, especially with lighter paper grades and at high running speeds.

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As regards the state of the art relating to the invention, reference is also made to the applicant's *FI patent applications 981330 and 981331*. Of these, FI patent application 981330 presents an integrated paper machine, which may be used for making paper of a good quality and with a high coefficient of efficiency at a speed in excess of 2000 m/min and which is shorter than the paper machine of today.

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FI patent application 981331 presents a paper machine intended especially for making such paper, which has copying paper properties as well as good gloss and suitable porosity for colour powder printing.

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Figure 1 is a cross-sectional view of traditional paper according to the known state of the art. In order to get surface sizing layers 11, the present-day surface sizing of base paper 1 for fine grade paper typically uses pastes of a low dry matter content (8 – 12 %), in order to ensure penetration of the coating paste through the paper; this means, that the size pressed into the paper from different sides must “meet” in the middle of the paper and form a bond 2 increasing the strength of the paper. Thus, the purpose of using a paste with a low dry matter content (8 – 12 %) is to lower the viscosity of the coating paste to be applied. With the present-day technique this is necessary to achieve sufficient strength characteristics, because when increasing the dry matter content of the paste the size will remain in the surface layers of the paper and desired bonds are not formed in the internal parts of the paper or board.

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The use of pastes with a low dry matter content (8 - 12 %) means that the paper is wetted “throughout” and thus much drying is needed afterwards and runability problems will result in the post-drying section. The increase of the coating paper’s dry matter content alone reduces the paste’s penetration into the paper or board and thus causes poorer strength characteristics in direction z. On the other hand, a reduction of the viscosity of a high-consistence paste by only changing the characteristics of the starch easily leads to increased curling and waviness tendencies.

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The problems with base paper or board in office papers are distributions of the paper or board in direction z, especially filler distribution, which in copying paper ought to be of such a type that there is less filler on the surfaces in view of dusting. On the other hand, with office papers the aim is to use the paper or board in many ways, that is, the paper or board should also be suitable for use in ink-jet printing, whereby

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filler is needed in the surface to achieve a dense surface.

It is an objective of the invention to bring about an inventive method of a new kind for making a surface-sized paper or board web in such a way that pastes with a higher dry matter content (>15 %, preferably 15 – 25 %) can be used without having to be content with poorer strength characteristics of the produced web or with poorer web runability. It is a particular objective of the invention to reduce investment costs by developing a paper and board machine, which is shorter than the known solutions, for making paper and board grades traditionally requiring pre-coating and thus bring about an improved paper or board machine. In addition, it is an objective of the invention to bring about an inventive paper or board with a new kind of structure and with good strength characteristics and suitable for very different purposes of use.

These objectives are achieved with the method mentioned in the beginning for making a coated fibre web, such as a paper or board web, the characteristic special features of which are presented in the characterising part of the following independent claim 1, with an improved paper or board machine, the characteristic special feature of which are presented in the characterising part of the following independent claim 10, and with a coated paper or board, the characteristic special features of which are presented in the characterising part of the following independent claim 19.

Considerable advantages are achieved with the invention:

- From the high dry matter content (>15 %), preferably 15 – 25 %) of the coating paste follows, when it is desirable to apply into the web and press into its surface layer or layers a smaller amount of coating paste (g/m^2), a higher dry matter content after the surface-coating section, which results in less need for post-drying and in a better runability of the post-drying section,
- The chemicals of the intermediate layer (strength characteristics in direction z) and the surface layer (surface strength) can be optimised independently of each

other.

- When single-wire transfer is used, the curling tendency caused by the post-drying section is reduced, as less post drying is needed. The required curling control equipment based on wetting can also be abandoned, which further
5 reduces the need for post drying.
- The paper to be produced has multi-use characteristics (copying, ink-jet).

According to the invention, additive and filler layering into the pulp is used in a multi-layer headbox and admixing of additives or fillers into the pulp is used in a
10 single-layer headbox, which replaces the state-of-the-art pre-coating to be performed in the finishing section. In additive and filler layering, the pulp can be divided into three different pulp flows for the body or base layer, that is, for the base paper's or board's surface layers and middle layer, whereby the desired additives and fillers are conducted into each, especially starch to bring about layer structures of different
15 kinds. When required, the additive and filler may be supplied from several different points or in several different steps into the pulp flow. According to an advantageous application of the invention, fines may also be added. In addition, fibre layering may advantageously be used in connection with the invention, where the fibre pulp is separated for the surface and middle layers of the base paper or board separately,
20 so that a fibre pulp of the desired type is led into the surface layer of the base paper or board, or correspondingly, into the middle layer of the base paper or board. In addition, retention matter known in the state of the art may be used to bind the filler and fines into the surface, which will prevent them from moving away together with the water from the surface layers of the paper or board. The retention matter may
25 also be supplied layer-wise.

Thus, according to the invention, pre-coating is integrated in the first part of the paper or board machine and additives and fillers are led into the web surface immediately in the early stage of the web manufacture. In this way a sufficiently
30 small pore size is achieved in the surface of the body or base layer, that is, the base paper or board, so that the actual surface-coating paste, preferably a surface-sizing

paste, to be applied stays in the surface of the base paper or board. In this way an advantageous surface for a printing process is also achieved, from which printing colour will not penetrate deeply into the web.

5 With the invention, such a pore size can be achieved in the paper or board, which is 1/10 of its original value. An optimum surface sizing coverage is attained, when the pores in the surface of the base paper or board are so small that surface sizing will not penetrate into them and thus remains on the surface. This is achieved by adding the additives and fillers into the pulp flows even before the headbox, and
10 advantageously by using at the same time fibre layering and possibly by adding fines into the pulp flows to be supplied into the surface layers of the base paper or board.

Thus, in the invention pre-coating is replaced by layering of additives and fillers into the pulp flows to be supplied to the headbox, whereby process efficiency is
15 improved and investment costs are reduced. According to an advantageous application, the paper or board machine according to the invention, wherein pre-coating is replaced by an additive and filler layering technique into the pulp flows of the headbox, includes a multi-layer headbox, a jaw former, a press section, a drying section, a surface-coating station/stations and a multi-nip calender and a reeler.

20 In the method according to the invention, short circulation and a headbox can be applied, which allows layering of additives, fillers and/or fines. One such pulp supply arrangement advantageous for application in the invention is presented in *FI Patent 92729*. The fillers, fines and additives can also be supplied only in the
25 headbox itself. One such arrangement is described in *printed patent specification EP 824157*. Short circulation arrangements may be generally known already as such in the state of the art, but it is especially advantageous in connection with the invention to apply such a short circulation marketed by the applicant under trademark **OptiFeed™**, which is described e.g. in *FI Patent 103676*. By using the OptiFeed™
30 arrangement pulp volumes are minimised in the short circulation, for which reason e.g. grade exchange can be made quickly on a paper or board machine according to

our invention without any long troubles e.g. in pulp proportioning.

Thus, in the paper or board machine according to the invention there are a short circulation and a multi-layer headbox or single-layer headbox, which allow at least layering or mixing of fillers. The former used is preferably a jaw former, which allows higher speeds than formers of other types and a possibility to perform dewatering bilaterally, whereby a symmetrical paper is obtained. One such jaw former is e.g. the wire section marketed under the applicant's trademark **OptiFormer™** or a former of a corresponding type, which is described in the mentioned paper *L. Verkasalo: Efficient Forming at High Speeds, XI Valmet Paper Technology Days 1998*.

In the paper or board machine according to the invention, known press solutions can be utilised, but in several cases it is most advantageous to use long-nip pressing. With a so-called shoe press good bulk and high dry matter are achieved and also as little asymmetry as possible in the web. When using e.g. the applicant's double-felt **OptiPress™** press section, symmetrical dewatering is achieved as well as a web having symmetrical surface characteristics. When aiming at high dry matters, it can be advantageous to replace one felt with a fabric, a so-called transfer belt, which does not receive water and which transfers the web well. Although the invention does essentially reduce the need for separate coating equipment, it may be advantageous in some applications to combine the press section with surface sizing, whereby a separate surface sizing unit after the drying section and the associated further treatments are not necessarily needed. One such solution (wet end sizing) is described e.g. in *US Patent 4793899*,

The invention makes no special demands on the drying section, but it is possible in connection with the invention to apply known state-of-the-art drying solutions, e.g. a drying section applying single-wire transfer, with which on-blowing can also be combined in order to achieve drying efficiency, profiling or a swift grade exchange. Such a modern drying section is presented e.g. in the international patent application

5 *PCT/FI98/00945*. With paper grades in particular it is advantageous to use the drying section marketed under the applicant's trademark **OptiDry™** or a drying section of a similar type. When desired, such pre-calendering may be used on the drying section, which is presented e.g. in *FI Patent 104434*, wherein calendering drying against a cylinder is presented. Naturally, pre-calendering may also be performed between two rolls. When needed, pre-calendering can of course be done traditionally after the drying section.

10 There is no pre-coating in the final end of the paper machine or board machine according to the invention, because coating was done in the headbox, whereby fillers and/or starch was layered, and no surface sizing was done, except a possible wet end surface sizing in the press section. Under these circumstances, as the paper or board arrives from the actual drying section, it is surface-coated at one or more surface-coating stations, which is followed by an on-line or off-line multi-nip calender.

15 In those applications of the invention, where the web is also coated separately at a coating station, e.g. a blade coater, or a coater of the jet, film transfer or spray type is used in the coating. Using the coater, the coating matter is transferred freely on to the web surface either as a coherent jet or as a spray, or the coating is applied by a roll. It is advantageous to use e.g. the coater marketed by the applicant under the tradename **OptiCoat Jet™** or a coater of a corresponding type.

20 In order to eliminate web breaks, the web may be coated supported by a belt. Supported coating is presented e.g. in the applicant's Finnish patent FI 101489 and
25 in article *1998 Coating/Paper Machine Makers Conference, TAPPI Proceedings*.

The drying after surface coating may be started by non-contact drying, e.g. by using the drier marketed by the applicant under the tradename **PowerDry™** or a drier of a corresponding type, with which a high drying power is achieved and a quick change
30 of drying power when required. In actual fact, thanks to the invention, non-contact drying may even form the main form of drying, so that the following short bank of

cylinders after it mainly functions as a driving bank.

Then advantageously follows a multi-nip calender, which is preferably an on-line calender marketed by the applicant under trademark **OptiLoadTM** or a calender of a corresponding type, which differs from the ordinary super calenders in that its linear loads in each nip can be controlled separately. Thus it is possible to save bulk, but to achieve a good gloss and smoothness. As regards a calender of this type reference is made to *FI Patent 96334*. In connection with the invention it is of course also possible to apply off-machine calenders.

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Then follows the reeler, preferably the reeler marketed by the applicant under trademark **OptiReelTM** or a reeler of the same type, which is suitable for uniform reeling of the web.

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With the method according to the invention it is possible to make paper or board that is similar to a web made with a state-of-the-art machine equipped with a pre-coating unit. However, the paper or board machine according to the invention includes no pre-coating unit, therein differing from the state of the art. According to an advantageous application of the invention, neither is a surface sizing unit needed, nor preferably any pre-calender.

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In the paper or board machine according to the invention, the need for post-drying is reduced essentially in comparison with the traditional post-drying section. Assume that the paper machine capacities remain the same and that the normal low dry matter content of the coating paste is approximately 10 %. As according to the invention the dry matter content of the coating paste can be increased highly, e.g. to about 20 %, and assuming that the base paper is dry when arriving in the surface-coating section, the post-drying section can be shortened to one-half of its present length, because the water quantity to be removed is only one-half of the normal quantity. If one-half of the coating paste is layered in the web already at the headbox, the water quantity to be removed in the post-drying section is further reduced to one-

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half. Thus, in a paper machine according to the invention the need for post drying is only 25 % of the present need, that is, only one cylinder bank is sufficient as the post-drying section instead of the earlier 12 cylinders in several banks, instead of the post-drying section. It should be noted in this context that it follows from the high
5 dry matter content ($>15\%$, preferably $15 - 25\%$) of the coating paste, when a smaller quantity of paste (g/m^2) should be applied into the web, that the dry matter content is higher after the surface coating section, which results in less need for post-drying and in a better runability of the post-drying section, and when single-wire transfer is used the curling tendency caused by the post-drying section is reduced,
10 when the need for post-drying is reduced. Hereby curling control equipment based on wetting can be abandoned, which further reduces the need for post-drying.

It should be noted in particular in connection with the invention that several techniques to be used in the method and in the paper or board machine according to
15 the invention have become separately known only in recent days.

As regards the other special features of the invention reference is made to the dependent claims in the set of claims.

20 In the following, the invention will be described in greater detail referring to the figures in the appended drawing, but the purpose is not to restrict the invention in any strict manner to the details shown in the figures.

25 Figure 2 is a schematic view of the improved paper or board machine according to the invention, and

Figure 3 is a cross-sectional view of the paper or board according to the invention.

The advantageous example shown in Figure 2 of the paper or board machine according to the invention for implementing the method according to the invention
30 includes, first, a headbox 100, which is preferably a multi-layer headbox as shown in the figure.

In the multi-layer headbox 100, the pulp is layered in such a way that the pulp flows to be conducted into the surface layers include fillers and additives, e.g. starches and hydrofobic sizes and possibly a retention matter. In addition to the layering of additives and fillers, fines may be layered into the surface layers when required or fibre layering may be used at the same time. If it is advantageous for the final product, the arrangement according to the invention in the multi-layer headbox allows desired fillers, additives and fines to be conducted into the desired layer, e.g. a supply of any required fillers and additives and other such matter into the middle layer. However, it is essential for the invention that in the multi-layer headbox starch and optionally hydrofobic size is conducted into the pulp through at least one layer in the multi-layer headbox. When the multi-layer headbox is a 3-layer headbox, a conventional quantity of starch is layered into the middle layer part of the base or body layer 1 (compare with Figure 3), that is, of the base paper or board. But when the headbox is a 1-layer headbox, a quantity of starch in excess of the normal quantity is admixed into the base paper or board. The headbox is followed by a wire section 200. The headbox 100 and the wire section 200 have such a structure that in direction *z* a layered structure of the paper or board web is achieved and/or a desired distribution of additives or fillers is achieved in direction *z* (see the applicant's patent *EP 0 651 092*). The occurrence of porosity can be enhanced by using either one or a negative pressure suitable for the purpose in support of the retention matter added before the headbox 100. However, it is also important that a good formation is achieved. The wire section 200 should be such that it will not damage the achieved layering. The jaw former 250 shown in the figure is well suitable for this purpose, but formers of other types are suitable at least partly for use. Wire section 200 is followed by a press section 300. As shown in the figure, a long-nip press, e.g. a shoe press 350, 360, is used in the press section 300, and in this way preconditions are brought about for preservation of the porosity. The press section 300 shown in the figure includes two presses 350, 360. The front drying section 400, which follows after press section 300, is formed by an on-blowing drying section 450 and a conventional cylinder drying section 460, which includes drying banks R_{1-N} applying

single-wire transfer. Of the drying banks at least one is formed by a large-diameter cylinder 420 located in a cellar space and by on-blowing drying equipment 422 placed in connection with cylinder 420. After the front drying section 400 a film size press 500 is located, which is followed by a post-drying section 600 formed by drying banks R_j applying single-wire transfer, a shoe calender 700 and a reeler 800.

In the paper or board machine according to Figure 2, the fibre web F, such as a paper or board web, travels as follows. From the multi-layer headbox 100 the pulp is supplied into a jaw between the former rolls 210, 220 of the jaw former 250 of wire section 200, from which jaw it is conducted in between wires 215 and 216 past dewatering equipment 230 and further supported by wire 215 on to the press section 300. Press section 300 includes two presses 350 and 360, and at the top fabric 315 of the first press the web W is conducted between press rolls 311, 310 of press 350 supported by bottom fabric 316. From bottom fabric 316 the web W is conducted on to the top fabric 317 of the next press 360 and further in between top fabric 317 and bottom fabric 318 in between press rolls 321, 320 of press 360. Each press 350, 360 is formed as a shoe press. From press section 300 web W is guided on transfer fabric 390, whereby vacuum box 391 keeps web W on the fabric, into an on-blowing drying unit of drying section 400, wherein web W travels supported by bottom fabric 451 past on-blowing drying unit 450 into $R_1 - R_N$ of drying section 400, which apply single-wire transfer. Of the cylinder drying banks R_2 is formed in such a way that it includes a large-diameter cylinder 420, which is placed in the cellar and in connection with which on-blowing drying 422 is arranged, in which drying bank the web travels supported by wire 425. The drying wire of drying banks applying single-wire transfer is indicated by reference number 415 and the heated drying cylinders of the top row are indicated by reference number 410, while the hitch cylinders or rolls of the bottom row are indicated by reference number 411. Web W travels in a zigzag fashion from the hitch cylinders/rolls 411 of the bottom row on to the heated drying cylinders 410 of the top row, on which web W is in direct contact against the heated cylinder surface. Then web W is guided through measuring equipment 490 on to film size press 500, the rolls of which are indicated by

reference numbers 545 and 547, while the film transfer devices is indicated by reference numbers 548 and 549. Through a non-contact reversing device 580 web W is guided to post-drying section 600, which according to the invention includes one drying bank R₁, which preferably applies single-wire transfer and includes a drying
5 wire 615 and heated drying cylinders 610 and hitch cylinders/rolls 611. After the post-drying section the web is wetted by either water fog or steam in order to eliminate any curling with the aid of device 650. Web W is then guided into calender 700, which is formed as a shoe calender and whose rolls are indicated by reference numbers 750, 751. After calender 700 web W is guided on to a reeler,
10 wherein web W is reeled by the reeler's reeling rolls 809, 810 into reels 811, 812.

According to the invention, the base paper or board, from which the base or body layer 1 of the paper product is formed, is optimally formed by in the headbox 100 layering filler, starch and possibly hydrofobic sizes with a system for layering
15 additives, so that a suitable dense and hydrofobic surface 10 is achieved for further treatment, such as surface sizing.

By layering in the surface-coating section 500, such as in a film size press, a surface-sizing layer 11 into the surface 10 a bond/bonds 2 keeping the layer/layers 1, 11
20 together are formed in between the base or body layer 1 and the surface-sizing layer/layers 11. Bond 2 also affects the strength characteristics of the paper or board in direction z. When the surface-sizing layer 11 is starch, the dusting problems of normal copying paper are avoided as the pulp starch improves the surface strength as well as the binding of fillers and fines. When the surface-sizing layer 11 is
25 hydrofobic size, a suitable hydrofobic surface is brought about for penetration of the sizing into the paper or board (water retention) and for the important uniform absorption of ink into the surface of ink-jet paper, by which the ink is prevented from penetrating to deeply or from spreading out on the paper or board surface.

30 When in the multi-layer headbox 100 a base paper or board web W has been formed by layering, which web has essentially dense and hydrofobic surfaces 10 and which

has been taken through wire section 200 and press section 300 and front drying section 400 to the surface-coating section 500, surface sizing of the essentially dense and hydrofobic surface of the base paper or board 1 can be performed in the surface-coating section 500 with a high consistence coating paste, wherein the increased dry matter content has been achieved by a reduced quantity of starch and/or by an increased dry matter content of the size and which penetrates inside from the surface 10 of the base paper web or base board web forming a bond 2 between base paper or board 1 and surface sizing layer 11.

As is illustrated in Figure 3, in the surface coating to be performed after the front drying section, preferably in surface sizing, the coating paste is pressed only into the surface 10 of the layered base or body layer 1 of the paper or board in such a way that the bonds 2 in direction z of the paper or board are brought about in the internal parts of the paper or board in between the layered base or body layer 1 and the layers of chemicals 11 applied from the surface. Thus, in the paper or board product according to the invention the surface-coating layer 11 extends only to a part of the thickness of the base paper or board web and it forms a bond 2 in between the base paper or board 1 and the surface-coating layer 11.

Thus, chemicals to be surface sized need not be pressed through the entire paper or board. In addition, it is an advantage that the chemicals of the base or middle layer 1 (strength characteristics in direction z) and of the surface layer 11 (surface strength) can be optimised independently of each other and it is possible to make such paper or board which has multi-use characteristics (copying, ink-jet).

The invention was described in the foregoing only with the aid of its one embodiment, which is considered advantageous. Of course, this is not intended to limit the invention in any way to concern such an individual embodiment only. Thus, as is obvious to the professional in the field, many alternative solutions and modifications are possible within the scope of the inventive idea defined in the appended claims.

Claims

1. Method for making a coated fibre web, such as a paper or board web, in which method the pulp, in which additives, fillers and fines as well as retention matter are mixed, is supplied from the headbox (100) on to a wire section (200), where water is removed from the web (W); the web (W) is guided from the wire section (200) to the press section (300) for removing water from the web (W); the web (W) is dried in a front drying section (400); the web (W) is coated in a coating section (500); the web (W) is dried in a post-drying section (600); and the web (W) is reeled by a reeler (800), characterised in that into the pulp to be fed from the headbox (100) to the wire section (200) starch and/or hydrofobic size or sizes are admixed or layered, so that into at least one layer of the web (W) to be guided through the wire section (200) and press section (300) and front drying section (400) into the coating section (500) an essentially dense surface (10) is formed, on to which such a coating paste or starch is spread out, which has a high dry matter content, whereby a bond (2) is achieved in direction z inside the web (W) between the base or body layer (1), that is, the base paper or board, and the coating paste or starch layer (11) spread out on the surface.
2. Method according to claim 1, characterised in that the base paper or board (1) is formed by layering in the pulp flows to be conducted into the headbox (100) filler, starch and/or hydrofobic sizes by a system for layering additives, so that an essentially dense and hydrofobic surface (10) is achieved for surface-coating, preferably surface sizing, included in the further treatment.
3. Method according to claim 1 and 2, characterised in that in the surface coating such surface-coating or sizing paste is spread out, the dry matter content of which is > 15 %, preferably 15 – 25 %.
4. Method according to claim 2, characterised in that in the headbox (100) starch and optionally size is conducted into the base paper or board (1) to be formed in

order to bring about a dense and hydrofobic surface (10) for surface coating.

5. Method according to claim 4, **characterised** in that starch and optionally size is supplied into at least one layer in a multi-layer headbox (100).
- 5 6. Method according to claim 5, **characterised** in that starch and optionally size is layered mainly in the middle layer of the pulp forming the base paper or board (1), when the headbox (100) is a 3-layer headbox.
- 10 7. Method according to claim 4, **characterised** in that starch and optionally size is admixed into the pulp forming the base paper or board (1), when the headbox (100) is a 1-layer headbox.
- 15 8. Method according to any one of claims 2 - 7, **characterised** in that surface sizing of the essentially dense and hydrofobic surface of the base paper or board (1) is performed in the coating section (500) with high consistence coating paste, wherein the quantity of starch has been reduced and/or where the dry matter content of the size has been increased.
- 20 9. Method according to any one of claims 1 - 8, **characterised** in that the surface coating is performed in connection with the press section (300).
- 25 10. Improved paper or board machine for making a coated fibre web, such as a paper or board web, which paper machine includes a headbox (100), and into the pulp to be supplied to the headbox additives, fillers and fines have been admixed as well as retention matter, a wire section (200) for forming the web (W) and for removing water from the web (W); a press section (300) for pressing water from the web (W); a front drying section (400) for drying the pressed web (W); a coating section (500) for surface-coating of the web (W); a post-drying section
30 (600) for drying the coated web (W); and a reeler (800) for reeling the web (W), **characterised** in that the pulp to be supplied contains starch and/or hydrofobic

size or sizes, so that into at least one layer of the web (W) to be guided through the wire section (200) and the press section (300) and the front drying section (400) into the coating section (500) an essentially dense surface (10) is formed, on which in the surface coating a coating paste or starch is spread out, which has

5 a high dry matter content, whereby a bond (2) is achieved inside the web (W) in direction z between the base or body layer (1), that is, the base paper or board, and the coating paste or starch layer (11) spread out on the surface.

11. Paper or board machine according to claim 10, **characterised** in that the base paper or board (1) is formed by layering in a multi-layer headbox (100) filler, starch and optionally hydrofobic sizes by a system for layering additives, so that

10 in the web (W) an essentially dense and hydrofobic surface (10) is formed for further treatment, which includes surface coating, preferably surface sizing.

12. Paper or board machine according to claim 10, **characterised** in that the dry matter content of the surface-coating paste to be spread out on the web surface (10) in the surface-coating section (500) is >15 %, preferably 15 – 25 %.

15

13. Paper or board machine according to claim 10 and/or 11, **characterised** in that there is starch and optionally size in the base paper or board to be supplied from

20 the headbox (100) into the wire section (200).

14. Paper or board machine according to claim 11, **characterised** in that in the multi-layer headbox (100) starch and optionally size have been supplied at least

25 through one layer of the multi-layer headbox (100).

15. Paper or board machine according to claim 14, **characterised** in that starch and optionally size have been layered mainly in the middle layer of the pulp forming the base paper or board (1) through the middle layer of a 3-layer headbox.

30

16. Paper or board machine according to claim 10, **characterised** in that a 1-layer

headbox (100) admixes starch and optionally size into pulp forming the base paper or board (1).

- 5 17. Paper or board machine according to any one of claims 11 - 16, **characterised** in that surface coating of the essentially dense and hydrofobic surface of the base paper or board has been performed in the coating section (500) with a high consistence coating paste, wherein the quantity of starch has been reduced and/or wherein the dry matter content of the size has been increased.
- 10 18. Paper or board machine according to any one of claims 10 - 17, **characterised** in that the surface coating is integrated into the press section (300).
- 15 19. Coated paper or board, including the paper product's base or body layer (1), that is, the base paper or board, and at least one surface-coating layer (11), **characterised** in that an internal bond (2), which is located in between the base or body layer (1) and the surface-coating layer (11) and which holds the layers (1, 11) together affects the paper's or board's strength characteristics in direction z.
- 20 20. Paper or board according to claim 19, **characterised** in that the surface-coating layer (11) is starch.
- 25 21. Paper or board according to claim 19, **characterised** in that the surface-coating layer (11) is hydrofobic size.
- 30 22. Paper or board according to any one of claims 19 - 21, **characterised** in that in the base paper or board (1) of the paper or board at least one layer is starch and optionally hydrofobic size, that on the essentially dense and hydrofobic surface (10) of the base paper or board there is a surface-coating layer (11), which extends over a part of the thickness of the base paper or board web and forms a bond (2) in between the base paper or board (1) and the surface-coasting layer

(11).

23. Paper or board according to any one of claims 17 - 20, characterised in that the high dry matter content of the surface-coating paste has been achieved by a reduced quantity of starch and/or by an increased dry matter content of the size.

PRIOR ART

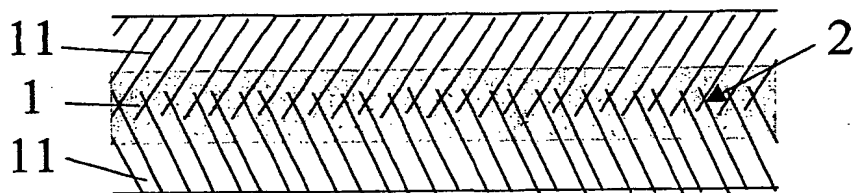


FIG. 1.

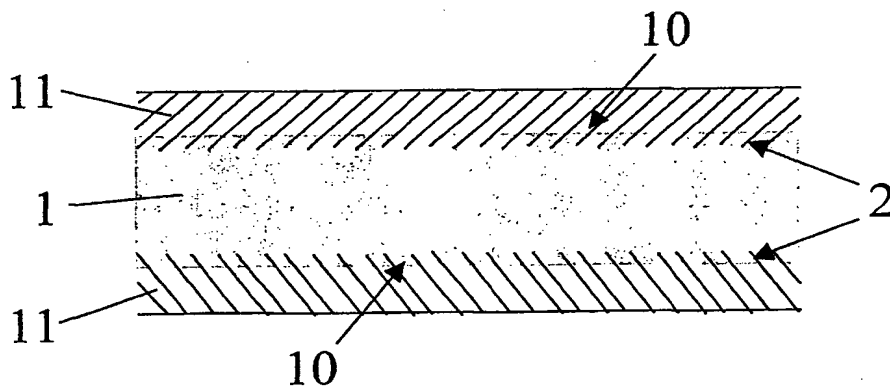


FIG. 3.

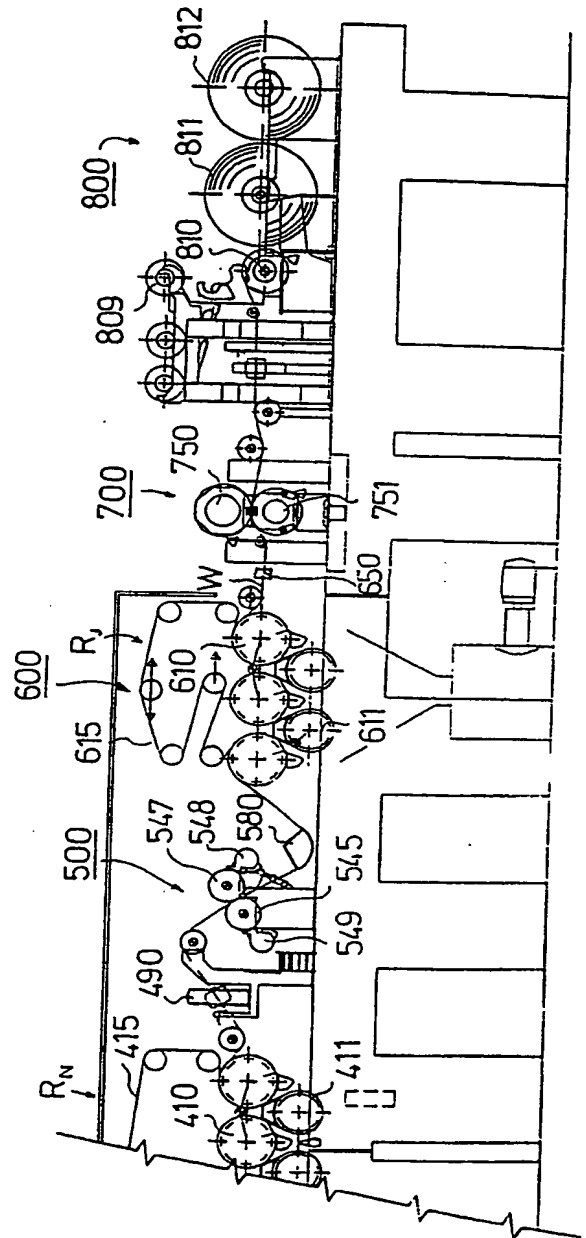
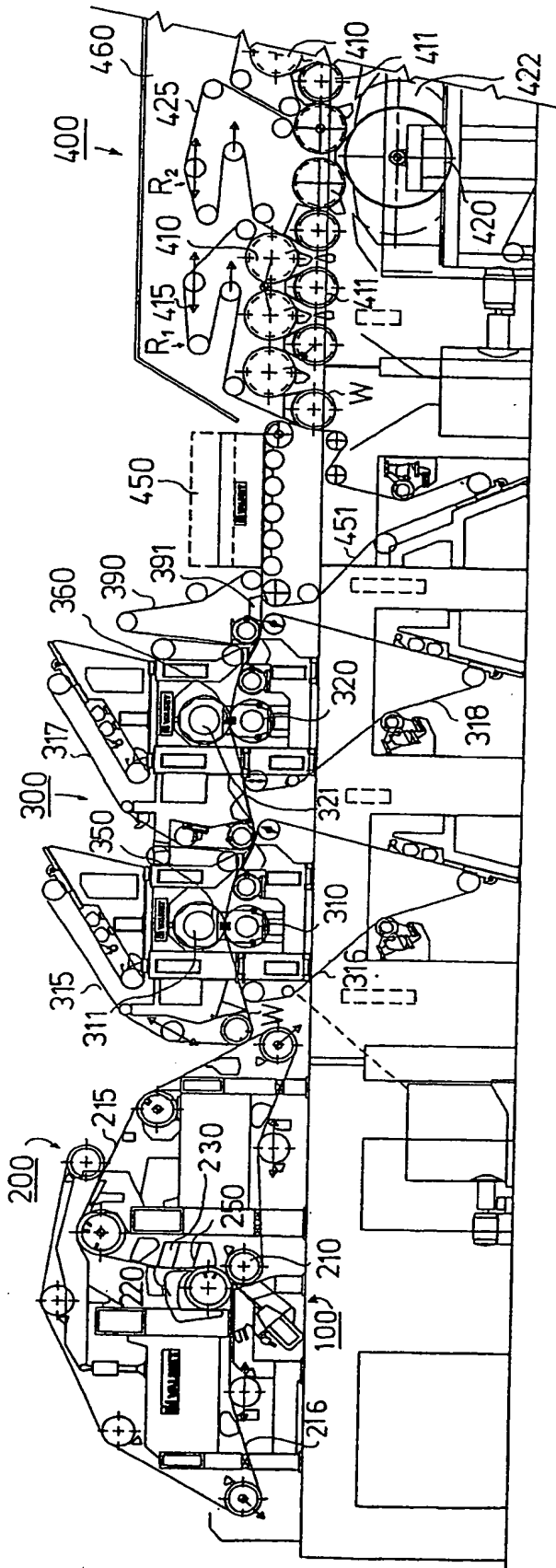


FIG.2.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI/00696

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D21H 19/54 // D21F 11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D21H, D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9964672 A1 (VALMET CORPORATION), 16 December 1999 (16.12.99), page 3, line 12 - line 14; page 7, line 3 - line 25, figure 1 --	1-18,23
X	GB 2026571 A (FRIEDRICH JOSEF ZUCKER), 6 February 1979 (06.02.79), page 1, line 11 - line 13; page 3, line 14 - line 27, abstract --	19-22
A	--	1-18,23
A	WO 9940256 A1 (VALMET CORPORATION), 12 August 1999 (12.08.99), page 5, line 26 - page 6, line 9 --	1-23

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

13 November 2001

Date of mailing of the international search report

16-11-2001

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/00696

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5837383 A (DONNA J. WENZEL ET AL), 17 November 1998 (17.11.98), column 5, line 38 - line 40 --	1-23
A	US 5952091 A (DIETER HORAND ET AL), 14 Sept 1999 (14.09.99), column 4, line 48 - line 49 -- -----	1-23

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/10/01

International application No.
PCT/FI 00696

Patent document cited in search report				Publication date		Patent family member(s)	Publication date
WO	9964672	A1	16/12/99	AU	4618499	A	30/12/99
				EP	1086272	A	28/03/01
				FI	981331	A	11/12/99
GB	2026571	A	06/02/79	AT	473279	A	15/09/83
				AU	4899279	A	31/01/80
				CA	1103968	A	30/06/81
				DE	2833452	A,C	07/02/80
				DK	317779	A	30/01/80
				FR	2433613	A,B	14/03/80
				IT	1122187	B	23/04/86
				IT	7924367	D	00/00/00
				JP	55022095	A	16/02/80
				NL	7905703	A	31/01/80
				SE	7906280	A	30/01/80
				SU	931113	A	23/05/82
WO	9940256	A1	12/08/99	AU	2280999	A	23/08/99
				BR	9907976	A	17/10/00
				EP	1070171	A	24/01/01
				FI	3632	U	30/09/98
				FI	103211	B	00/00/00
US	5837383	A	17/11/98	FI	980287	D,V	04/06/98
				AU	6786494	A	12/12/94
				EP	0697961	A	28/02/96
				US	5654039	A	05/08/97
				US	5763100	A	09/06/98
				US	5989724	A	23/11/99
				WO	9426513	A	24/11/94
				AU	3365395	A	07/03/96
				EP	0777575	A	11/06/97
				WO	9605054	A	22/02/96

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/10/01

International application No.

PCT/FI 01/00696

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	5952091	A	14/09/99	AT	171743 T	15/10/98
				CA	2187182 A	19/10/95
				DE	4411987 A,C	12/10/95
				DE	59503785 D	00/00/00
				DK	754260 T	08/02/99
				EP	0754260 A,B	22/01/97
				SE	0754260 T3	
				ES	2123976 T	16/01/99
				FI	963942 A	02/10/96
				JP	9511552 T	18/11/97
				WO	9527824 A	19/10/95

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